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THE EFFECT OF NOISE EXPOSURE DURING PRIMARY FLIGHT TRAINING ON THE CONVENTIONAL AND HIGH FREQUENCY HEARING OF NAVAL AVIATION OFFICER CANDIDATES

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Naval Aerospace Medical Research Laboratory
Pensacola, Florida

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The Effect of Noise Exposure During Primary Flight Training on the Conventional and High Frequency Hearing of Naval Aviation Officer Candidates

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13. ABSTRACT

This investigation was part of a larger study conducted by Memphis State University which was designed to explore the relationship between aviation noise exposure history and high-frequency hearing sensitivity. The NAMRL portion of the study focused on administering conventional audiometry (manual and self-recording), high-frequency audiometry (4 kHz - 18 kHz), and a speech intelligibility test in noise (Modified Rhyme Test) to 108 Naval Aviation Officer Candidates prior to the following primary flight training (approximately 25-28 hours) in T-34 aircraft. Hearing protection consisted of either the APH-6C or APH-6D flight helmet. Cockpit noise levels in the T-34 range from 96-115 dBA; during cruise the noise level is approximately 100 dBA. Results indicate no significant change in hearing sensitivity or speech discrimination that could be attributed to noise exposure during primary flight training. Pre- and post-primary hearing levels obtained for the high frequencies compare favorably with high-frequency hearing levels obtained by Northern et al. (1968) for males in the age range 20-29 years. Questionnaire data indicated that a considerable number of the subjects had been exposed to potentially hazardous noise before entry into military service.

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INTRODUCTION

This investigation was part of a larger study conducted by Dr. John Fletcher, Psychology Department, Memphis State University (1973). It was designed to explore the relationship between aviation noise exposure history and high frequency hearing sensitivity.

This laboratory's portion of the study focused on administering conventional frequency audiometry (250 Hz to 8000 Hz) and high frequency audiometry (4-18 kHz) to 108 Naval Aviation Officer Candidates prior to and immediately following primary flight training at VT-1, Saufley Field, Pensacola. This is a six to eight week period in which the students spend 25 to 30 hours of flight time in the T-34 aircraft. In addition, pre-primary and post-primary data were obtained concerning the ability of the students to discriminate speech in noise.

BACKGROUND

In the early 1960's Dr. Wayne Rudmose developed a high frequency audiometer that utilized a Bekesy type discrete frequency tracking procedure. The unit produced frequencies in the range 4-18 kHz. The transducer was a Bruel & Kjaer (B&K) one inch condenser microphone used as an earphone.

The development of the audiometer prompted a number of studies into high frequency hearing. Probably the first study to look at the relationship between high frequency hearing and noise-induced hearing loss was one by Sataloff, Vassallo, and Menduke (1967). They found that noise has approximately the same deleterious effect at 10 to 14 kHz as it has at 4 and 6 kHz. They made no measurements above 14 kHz. In a comparison of noise exposed and non-noise exposed subjects in each of three age ranges (20-29 years, 30-39 years, and 40-49 years) the noise exposed subjects showed consistently poorer hearing at 10, 12, and 14 kHz.

Corliss et al. (1970) studied high frequency hearing levels of high school students aged 15-18 years. While no significant differences were found in a comparison of two large groups of non-noise exposed and noise exposed males, substantial differences (20-30 dB) were found between the hearing levels of a group of 15-18 members of a male rifle team (shooting three times a week) and a large group of non-noise exposed males of the same age range, for frequencies above 10 kHz. Northern et al. (1972) showed mean hearing threshold levels of subjects with a

history of noise exposure to be essentially the same as threshold levels of non-noise exposed subjects. It may be that a mere comparison of a group of subjects having no history of noise exposure with a group of subjects having a non-specific noise exposure history is not sensitive enough to reveal any differences. The term "noise exposed" needs to be well defined.

Normative studies on high frequency hearing have been conducted with regard to the reliability of high frequency threshold testing (Fletcher, 1965) and the relation of high frequency hearing sensitivity to age and sex (Zislis and Fletcher, 1966). Threshold results obtained from sixth to 12th grade girls in the latter study have recently been recommended for use as an interim standard. Results of the most recent normative study were reported by Northern et al. (1972). The data were obtained during a field survey of high frequency hearing at a convention of the American Speech and Hearing Association. The data, obtained from 237 subjects and presented for decade age groups, indicate a general decline in hearing sensitivity for males 20-29 years from 8 to 16 kHz and a rapid decrement from 16 to 18 kHz.

METHOD

Subjects. A total of 265 subjects were tested immediately prior to their graduation from Schools Command. The group, consisting of both Aviation Officer Candidates (AOC's) and Aviation Reserve Officer Candidates ranged in age from 21 to 28 years. One hundred eight of the subjects were retested near or at the completion of their primary flight training. Data from the same subjects were utilized for the pre- and post-primary comparisons. During training all of the subjects wore the standard APH-6C or 6D flight helmet

Instrumentation. The Rudmose ARJ 4-HF audiometer or its prototype was employed to obtain hearing levels for the frequencies 4 to 18 kHz (Figure 1). It is a self-recording unit with a printed card output. One of the interesting features of this audiometer is the earphone (Figure 2). It is basically a Bruel & Kjaer one inch condenser microphone used in reverse. It was chosen because of its stability and its very wide frequency response characteristics. The acoustic signal is transmitted through a 1/8" tube lightly packed with steel wool to break up resonances in the tube. The completely assembled transducer is pictured in Figure 3. Note that the tube is covered by a conically shaped plastic tip that makes placement in the ear canal easy and produces a good seal. The plastic tip plays no role in the calibration of the transducer.

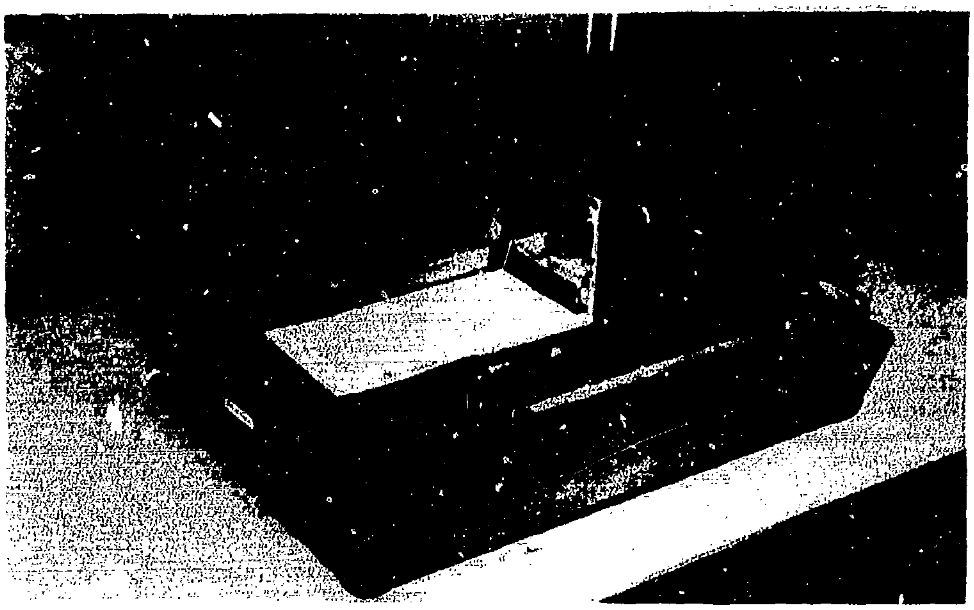

Figure 1. Prototype ARJ-4-HF audiometer manufactured by Rudmose Associates.

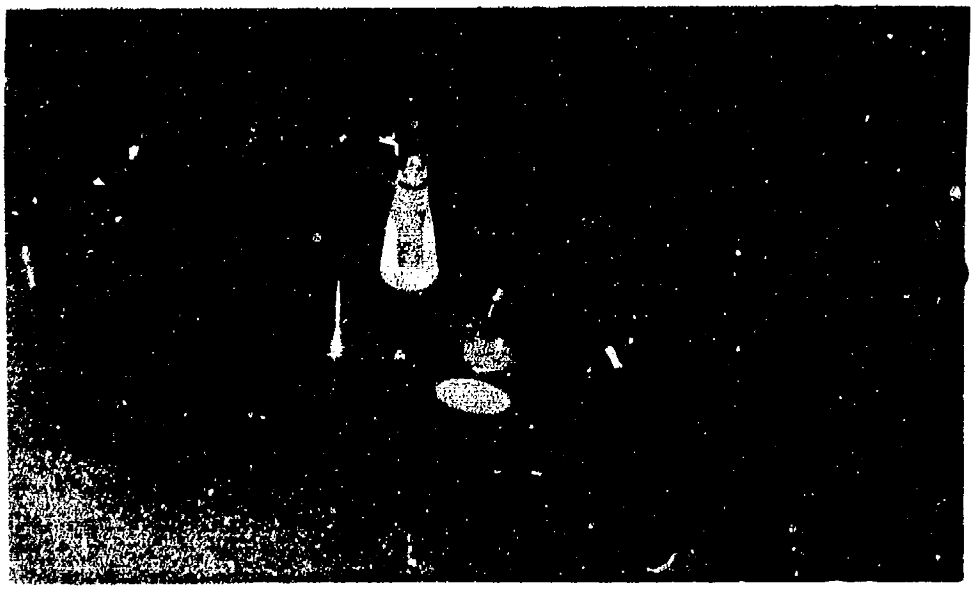

Figure 2. Disassembled high frequency earphone.

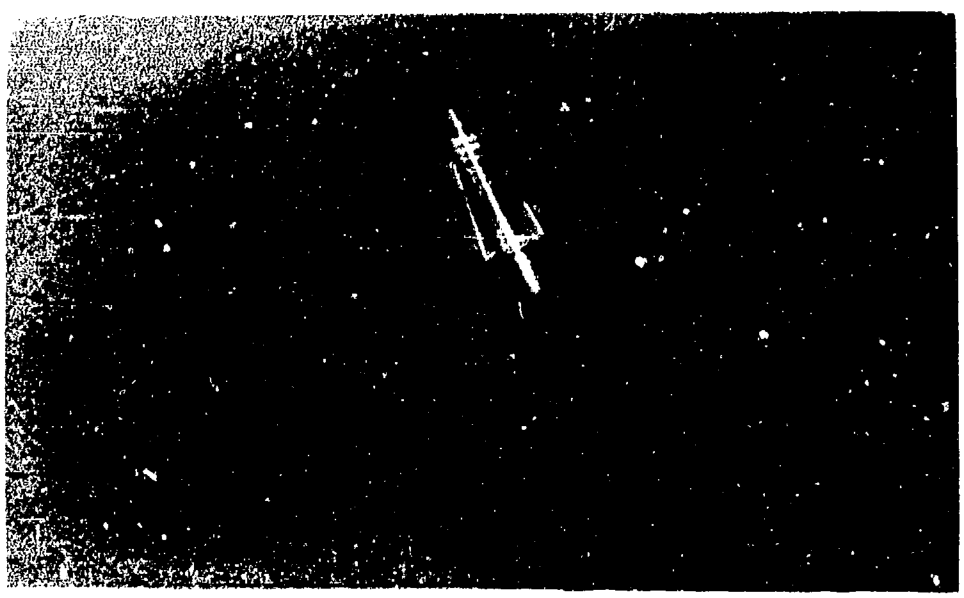

Figure 3. Assembled high frequency earphone.

Normally, calibration of the ARJ 4-HF audiometer involves placing the tip of the audiometer's earphone in close proximity and at grazing incidence to the diaphragm of a 1/2" B&K microphone which is associated with a B&K Precision Sound Level Meter (2203) and octave band filter set. As shown in Figure 4, the earphone is held securely in a clamp located on a tripod. With the audiometer output set at a fixed level, the sound pressure level (SPL) at the tip of the earphone tube is measured for each of the 12 test frequencies. The calibration reference utilized was that established by Rudmose.

Since the above procedure was a rather cumbersome method for frequent calibrations, a simpler method was devised. This technique is pictured in Figure 5. After each audiometer was first calibrated by the tripod method, the protective grid was removed from the B&K 1/2" microphone. A nose cone from a B&K probe tube kit was substituted in its place. The tube of the earphone was then seated in the nose cone. With the audiometer at the same fixed output setting as before, the relative meter readings produced by excitation of this small cavity by the earphone were recorded for future reference. All subsequent calibration checks utilized this latter procedure. It does not have the potential variability of the tripod technique and takes a fraction of the time.

Initially, the high frequency audiometers were physically calibrated each day the subjects were tested. However, when the extreme amplitude stability of the units became apparent, physical calibration intervals were lengthened. A typical example of stability was a 0 to 2.1 dB change over a five month period Biological checks were made each day of testing.

Conventional frequency audiometric thresholds were obtained on a Maico MA18 manual audiometer (.25, .5, 1, 2, 3, 4, 6 and 8 kHz) and a Tracor ARJ 4A self-recording audiometer (.5, 1, 2, 3, 4 and 6 kHz). An Ampex tape recorder (Model 350) was used to present the taped speech intelligibility test to subjects.

<u>Procedure</u>. Subjects were generally tested in pairs. For the pre-primary phase, the subjects were first briefed as to the purpose of the study and the general procedures to be followed (See Appendix A). To provide the subjects practice with the threshold tracking procedure, they were first administered conventional frequency self-recording audiometry in a multi-man Industrial Acoustics Corporation (IAC) test

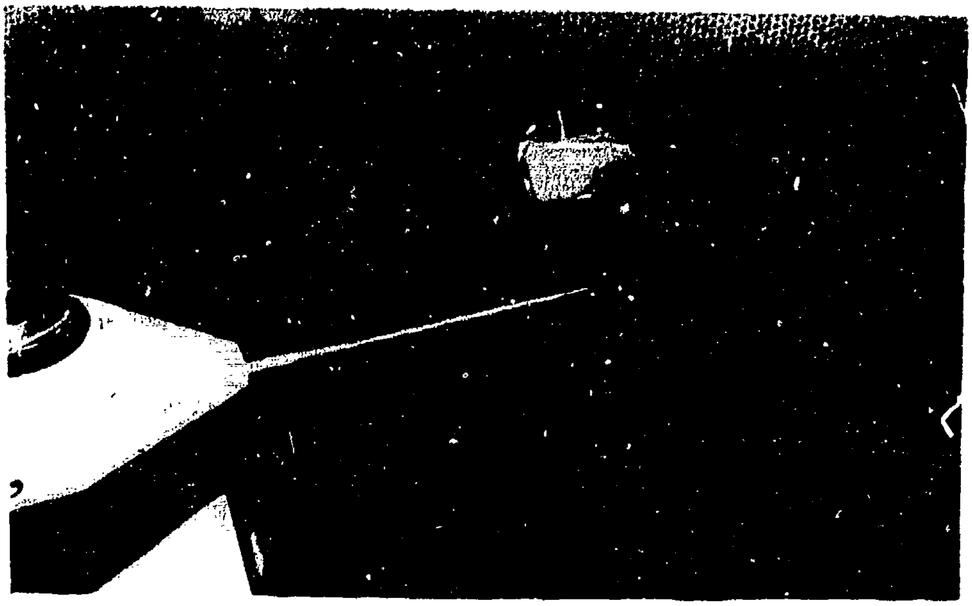

Figure 4. Tripod calibration technique.

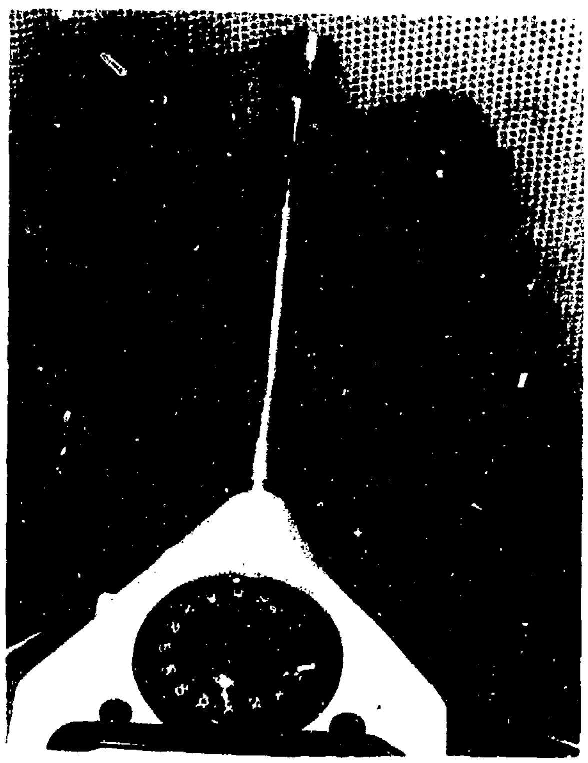

Figure 5. Calibration technique utilizing the nose cone from a Bruel and Kjaer probe tube kit.

booth. Following this, the first of two high frequency test runs was conducted with the subjects seated side by side in an IAC sound treated room. The right ear was tested first. Detailed instructions were given the subjects prior to testing. The subjects tracked their thresholds by means of a response button; test time per ear was six minutes. The transducer was hand held by the subject.

Following this, one subject of the pair was tested with the conventional frequency manual audiometer while the other completed a 24-item questionnaire. The questionnaire elicited responses in four general areas: medical history, noise exposure history, current noise exposure, and subjective reaction to noise. A copy of the questionnaire is shown in Appendix B. After manual audiometry and the questionnaire were completed, a second high frequency test was conducted. The time between the first and second high frequency tests was approximately 45 minutes.

Two speech intelligibility tests completed the test battery. The test employed was the Modified Rhyme Test or MRT (House et al. 1965). The taped test utilized was one developed by CHABA Working Group 52 for evaluation as a possible speech discrimination test for aviators. It consists of 50 words spoken by a male talker in a background of shaped noise. Two equivalent test lists were presented, one to each ear, at a speech-to-noise ratio of +4 dB. The MRT is a closed response test wherein the listener's task is to draw a line through one of six rhyming words which he thinks he heard. The pre-primary test battery took approximately two hours to complete.

The post-primary phase of testing followed the pre-primary phase by about 6 to 8 weeks. The subjects were again generally seen in pairs. After being questioned as to any interim high level noise exposure they had experienced other than the T-34 aircraft, they were given a high frequency test. This was followed by a conventional frequency test on the manual audiometer and a repeat of the same speech intelligibility tests administered during the pre-primary phase of the study. Post-primary testing took approximately one hour.

RESULTS AND DISCUSSION

Figure 6 shows for the left and right ears, respectively, mean high frequency hearing thresholds (expressed in sound pressure level) obtained during the pre-primary (1L, 2L - 1R, 2R) and post-primary (3L, 3R) test runs on 108 subjects. Corresponding numeric values and standard deviations

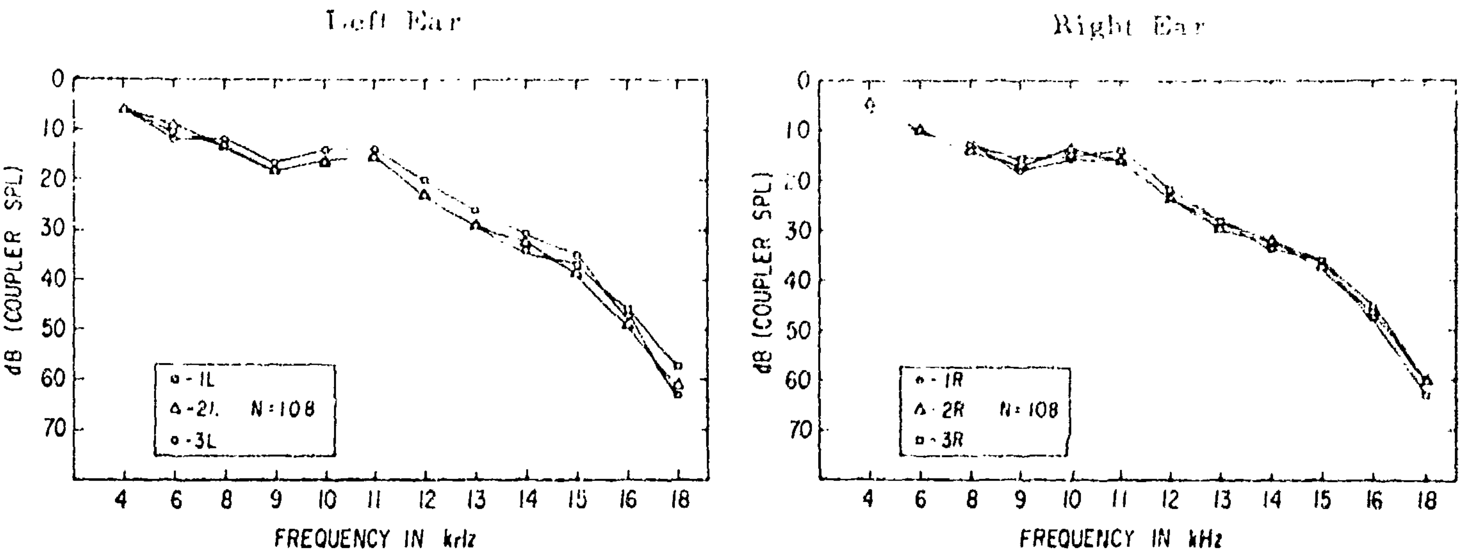

Figure 6. Mean hearing thresholds for each of the 12 high frequency stimuli obtained during the two pre-primary tests (1L, 2L - 1R, 2R) and post-primary tests (3L, 3R).

are shown in Tables 1 and 2. Ranges may be seen in Table 1 of Appendix C.

As can be seen, the mean pre- and post-primary thresholds are almost identical. The largest difference is only about 3 dB. As frequency increases, the sound pressure level required to reach threshold increases, reflecting a gradual fall off in hearing sensitivity. Mean thresholds for the two ears are almost identical.

Pearson product moment correlations calculated between the two pre-primary test runs (test-retest condition) ranged from .73 to .88 for the left ear and .62 to .77 for the right ear. The superior left ear correlations may have been due to a learning effect as the 1L, 2L tests represented the second and fourth subject tests during the pre-primary test phase. Correlations calculated between the second pre-primary test and the post-primary test ranged from .58 to .75 for the left ear and .51 to .74 for the right ear. Correlation values for all frequencies and test comparisons can be seen in Table 2 of Appendix C. These correlations are in good agreement with correlations obtained by Fletcher (1965) for short term test-retest of high frequency hearing (.60 to .92 vs .60 to .88).

It can be concluded from the foregoing data that noise exposure during the primary phase of flight training has no effect on hearing thresholds in the frequency range 4 to 18 kHz. The data also demonstrate the generally high reliability of the high frequency measurement technique.

In Figure 7 the data are presented in terms of the percentage of subjects responding to the different high frequencies. The numeric values are shown in Tables 1 and 2. For both left and right ears, nearly all of the subjects responded to frequencies 8 to 11 kHz. From 11 to 16 kHz there is a gradual decline in the percentage of subjects responding. At 18 kHz there is a marked decrease in the percentage of subjects responding - only 30 to 40 percent. Stated in another way, 60 to 70 percent of the subjects' thresholds at 18 kHz were beyond the maximum output of the audiometer (85 dB coupler SPL). Note that the percentage of subjects responding in the range 13 kHz and above was greater for the post-primary test than for either of the two pre-primary tests. This may be related to listening experience the subjects gained in operating their aircraft radio communications systems.

Figure 8 and Table 3 show mean thresholds obtained during the second pre-primary test for the right ear (N of 265) compared with mean threshold

Table 1

Mean pre- and post-primary high frequency hearing levels, right ear, in dB (coupler SPL) for number of subjects responding at each test frequency. Standard deviations are shown in parentheses. Also shown is the percentage of subjects responding at each frequency.

	Pre-Primary Test #1			Pre-Primary Test #2			Post-Primary		
Frequency (kHz)	N	Mean H.L.	Percent Responding	N	Mean H.L.	Percent Responding	N	Mean H.L.	Percent Responding
4	106	5.8 (15.8)	98	106	5.4 (13.5)	98	108	4.7 (13.1)	100
6	106	10.2 (17.1)	98	106	10.4 (16.9)	98	106	9.8 (14.7)	98
8	105	12.6 (17.3)	97	105	14.2 (16.2)	97	107	12.5 (15.3)	99
9	105	18.1 (18.7)	97	104	16.7 (15.7)	96	106	16.3 (15.9)	98
10	105	16.5 (18.9)	97	105	14.3 (15.5)	97	108	15.1 (16.6)	100
11	106	16.4 (20.7)	98	106	15.8 (18.2)	98	108	13.9 (18.0)	100
12	98	22.8 (19.1)	91	100	23.4 (17.2)	93	103	21.8 (16.4)	95
13	93	27.8 (16.8)	86	94	28.9 (16.4)	87	99	27.8 (16.2)	92
14	93	31.7 (18.2)	86	93	31.8 (17.3)	86	99	33.0 (18.5)	92
15	87	35.6 (20.0)	81	88	36.6 (19.5)	81	97	36.2 (19.2)	90
16	74	44.9 (22.0)	69	71	46.4 (20.5)	66	90	47.4 (20.7)	83
18	40	60.2 (14.5)	37	32	60.5 (14.4)	30	43	63.3 (15.2)	40

Table 2

Mean pre- and post-primary high frequency hearing levels, left ear, in dB (coupler SPL) for number of subjects responding at each test frequency. Standard deviations are shown in parentheses. Also shown is the percentage of subjects responding at each frequency.

	Pre-Primary Test #1			Pre-Primary Test #2			Post-Primary		
Frequency (kHz)	N	Mean H.L.	Percent Responding	N	Mean H.L.	Percent Responding	N	Mean H.L.	Percent Responding
4	106	6.4 (17.6)	98	106	5.7 (16.5)	98	108	5.6 (16.5)	100
6	106	10.4 (17.5)	98	107	11.5 (18.8)	99	108	11.7 (17.4)	100
8	105	13.0 (17.8)	97	107	13.3 (18.2)	99	107	12.8 (17.9)	99
9	107	18.3 (17.4)	99	106	17.4 (17.0)	98	107	17.4 (18.4)	99
10	107	16.2 (18.4)	99	106	15.7 (17.2)	98	106	14.5 (17.3)	98
11	106	14.7 (18.4)	98	106	14.9 (18.1)	98	107	14.1 (18.6)	99
12	102	22.7 (18.8)	94	102	22.7 (17.4)	94	105	19.8 (18.2)	97
13	97	29.5 (18.2)	90	98	29.3 (17.3)	91	102	26.3 (17.4)	94
14	96	33.9 (19.2)	89	96	31.9 (17.5)	89	99	30.6 (16.5)	92
15	88	37.4 (20.2)	81	90	37.9 (20.3)	83	97	35.4 (19.2)	90
16	67	45.8 (18.4)	62	73	48.6 (19.7)	68	86	47.5 (18.9)	80
18	31	57.3 (14.5)	29	33	60.6 (12.4)	31	49	63.3 (13.5)	45

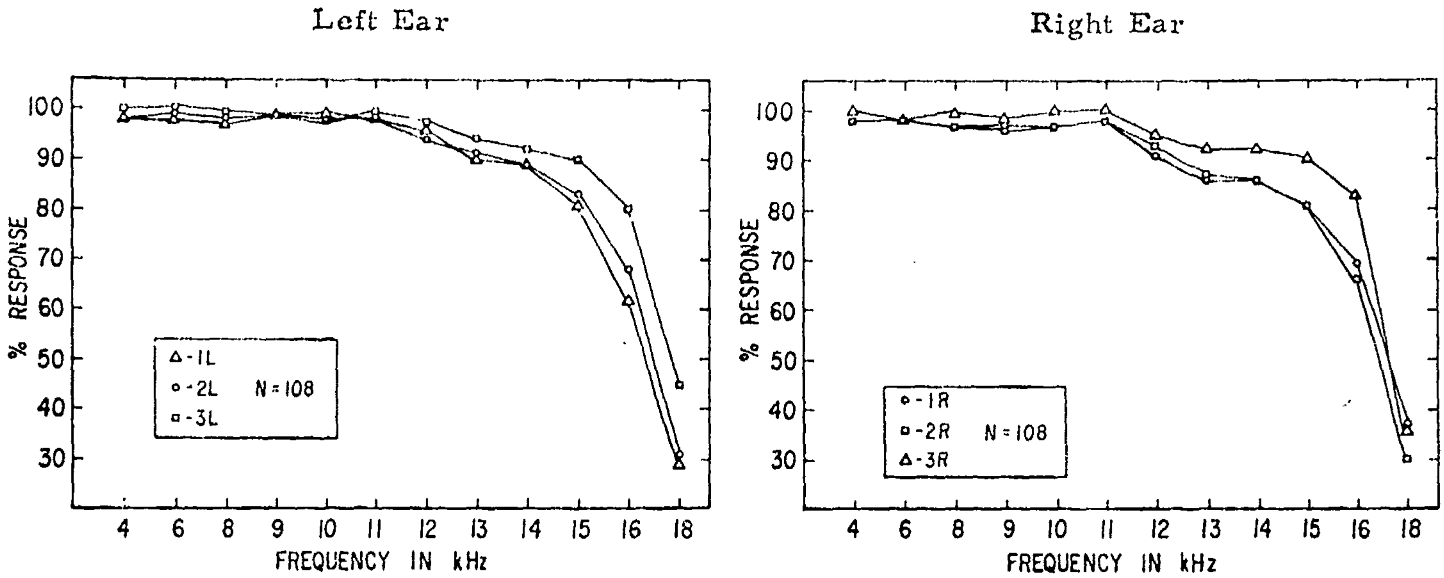

Figure 7. Percentage of subjects responding at frequencies 4 to 18 kHz during the two pre-primary tests (1L, 2L - 1R, 2R) and the post-primary tests (3L, 3R).

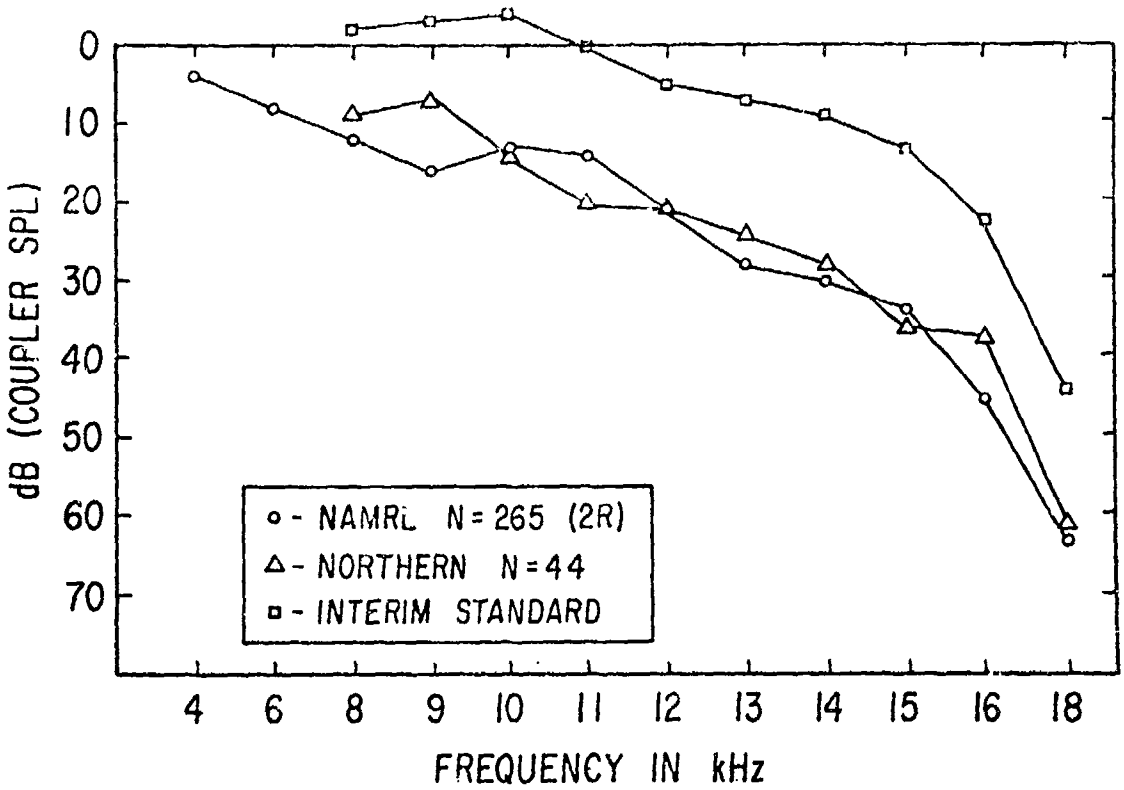

Figure 8. Comparison of mean hearing thresholds for the right ear (obtained from 265 subjects during second pre-primary test) with thresholds reported by Northern et al. (1972). The top curve is the suggested interim standard.

Table 3

Comparison of mean high frequency hearing levels in dB (coupler SPL) for the Northern et al. data, the present study and the suggested high frequency audiometric zero values.

Frequency (kHz)	Northern et al. 1973 (N=44)	Interim Standard	NAMRL 1973 (N=265)
4			3.8
6			7.9
8	9.0	-2.0	11.9
9	7.4	-3.0	16.3
10	14.3	-4.0	13.2
11	19.5	0.0	13.6
12	20.5	5.0	21.4
13	24.1	7.0	28.2
14	28.1	9.0	30.5
15	35.6	13.0	34.3
16	36.5	22.0	44.9
18	60.5	44.0	62.6

data obtained by Northern et al.(1972) for 44 subjects in the same age range as the AOC's. In view of the somewhat "noisy" life-style of the incoming AOC's, one might expect them to exhibit poorer high frequency hearing thresholds than young male adults in the field of speech and hearing. As Figure 8 shows, however, this is not the case. Mean thresholds for the two groups are remarkably similar. As mentioned earlier, in comparisons of this type, the terms "noise exposed" and "non-noise exposed" need to be well defined; this may account for the similar mean thresholds for these two groups of subjects. The clear differences in high frequency thresholds shown by Sataloff, Vassallo and Menduke (1967) were between a group of production workers in a paper mill ("noise exposed") and a group of individuals who worked in the executive offices of the same company ("non-noise exposed").

The upper curve in Figure 8 is the recently suggested interim standard for high frequency audiometric zero (Northern et al., 1972). As can be seen, it represents more sensitive hearing than that exhibited by either the AOC's or subjects in the Northern et al. study. It has been recommended because it probably represents the most sensitive hearing attainable for these frequencies. The recommended levels were derived from data collected on sixth through 12th grade girls collected by Zislis and Fletcher (1966). Even for this group of young non-noise exposed subjects, however, there is only about a 15 dB separation from the other curves. It might be hypothesized that high frequency hearing sensitivity deteriorates more rapidly from the effects of age, per se, than from the effects of a "noisy" life style.

In Figure 9 and Table 4 are shown the mean right ear high frequency threshold data obtained during pre-primary test 2 (N of 108) compared with similar data obtained from 50 incoming AOC's at NAMRL, Pensacola in 1963-64. While the statement is often made that our society is becoming progressively noisier, it is certainly not reflected in these comparable high frequency thresholds. As mentioned above, age, rather than generalized noise exposure, may be the major factor in the decline of high frequency hearing sensitivity. Although the data are not presented here, a comparison of conventional frequency thresholds for the 1963-64 AOC's and the AOC's in this study revealed no significant differences.

Conventional frequency hearing threshold levels obtained during the pre-primary and post-primary tests are shown in Figure 10. Numeric data are shown in Table 5. (Ranges may be seen in Table 3 of Appendix C.) Note in Figure 10, for both the pre- and post-primary tests, a depression of about 15 to 25 dB at 6 kHz (more pronounced for the left

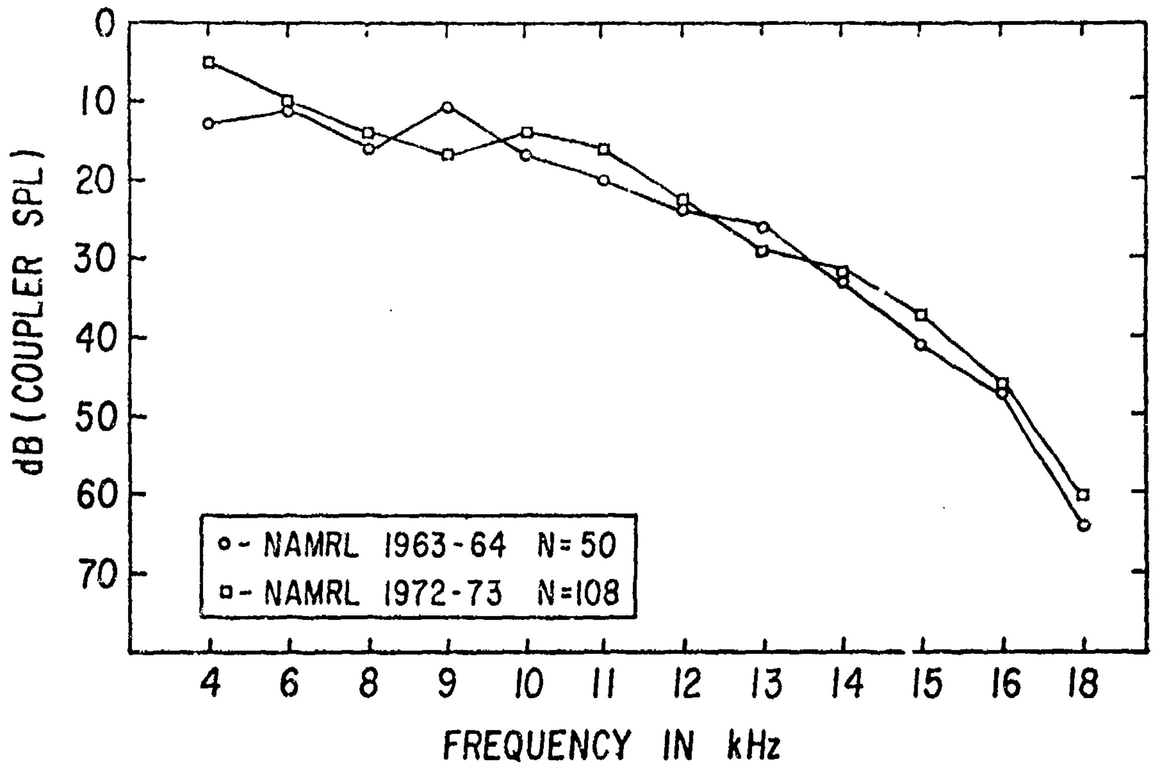

Figure 9. Comparison of mean hearing thresholds (right ear) with comparable data obtained at NAMRL from a group of 50 AOC's in 1964.

Table 4

Mean high frequency hearing levels in dB (coupler SPL) obtained in this study and in a 1964 NAMRL Study. Right ear.

Frequency (kHz)	NAMRL 1973* (N=108)	NAMRL 1964** (N=50)
4	5.4	12.5
6	10.5	10.9
8	14.3	15.7
9	16.7	11.1
10	14.3	16.6
11	15.8	19.9
12	23.4	23.8
13	28.9	25.8
14	31.8	33.3
15	36.6	40.6
16	46.4	46.8
18	60.5	63.1

*Second pre-primary test.
**Unpublished.

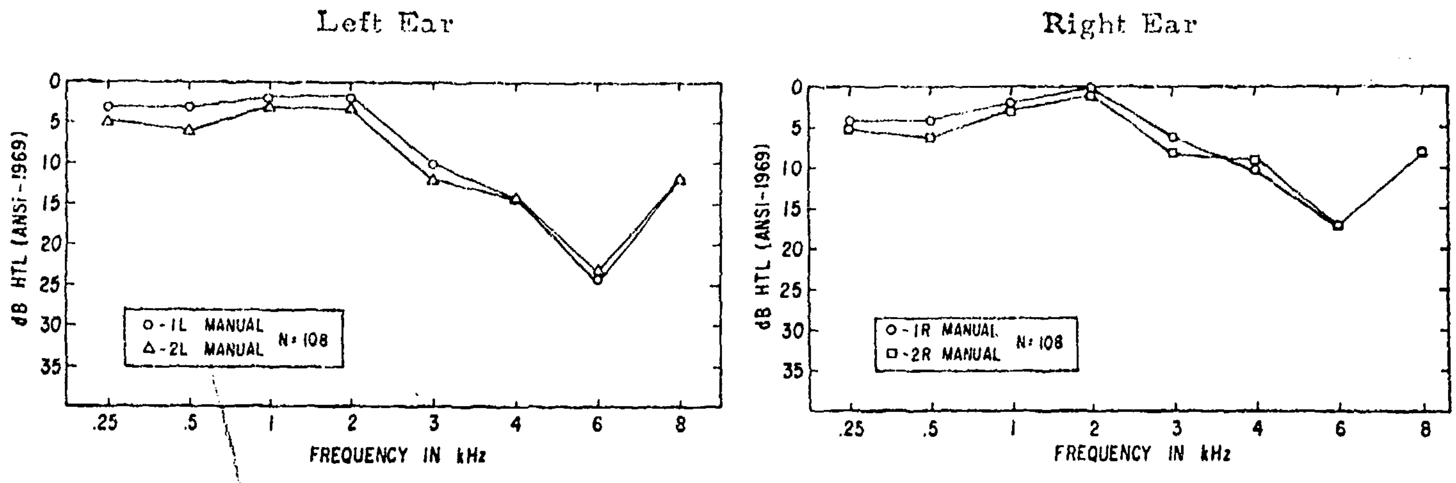

Figure 10. Mean conventional frequency thresholds for the pre-primary (1L, 1R) and post-primary (2L, 2R) tests.

Table 5

Mean pre- and post-primary conventional frequency hearing levels in dB (ANSI 1969) for the 108 subjects. Standard deviations are shown in parentheses.

	LEFT EAR		RIGHT EAR	
Frequency (kHz)	Pre-Primary H.L.	Post-Primary H.L.	Pre-Primary H.L.	Post-Primary H.L.
.25	2.6 (5.1)	5.0 (4.6)	3.8 (4.2)	5.3 (4.1)
.5	3.5 (5.8)	5.9 (5.7)	3.9 (5.1)	6.0 (5.2)
1	1.8 (5.8)	3.0 (5.9)	2.2* (5.1)	3.2 (4.8)
2	1.9 (6.8)	2.5 (6.5)	0.4 (6.0)	1.0 (5.9)
3	10.1* (11.4)	11.6 (10.9)	6.3* (8.6)	7.6 (8.1)
4	13.6 (16.7)	14.2 (16.6)	9.5 (11.5)	9.3 (11.7)
6	23.7 (19.1)	22.9 (19.7)	17.1 (16.7)	17.0 (17.6)
8	11.9 (16.0)	11.7 (17.4)	8.0 (14.8)	7.5 (14.8)

*N=107

ear), typical of the configuration of noise-induced hearing loss. While such a loss cannot be considered as a clinically significant impairment, it does indicate that the hearing sensitivity of the subjects, as a group, shows the result of excessive noise exposure prior to their entry into military service. As will be shown later, this is supported by the subjects' responses to the noise history questionnaire. There is a slight trend for the post-primary hearing threshold levels for frequencies 250 Hz and 500 Hz to be somewhat depressed. Although the magnitude of the depression is very small, it may reflect the result of possible middle ear pressure problems experienced by the subjects during training. The extremely close proximity of the pre- and post-primary group mean thresholds demonstrate that noise encountered during primary flight training had no significant effect on the subjects' mean hearing threshold levels for conventional frequencies.

Since individuals differ in their susceptibility to noise, individual subject data were examined with regard to threshold shifts at 3, 4, and 6 kHz. Twenty subjects (18.5 percent) showed a shift of 15 dB or greater at one or more of the three frequencies across ears, seventeen subjects showed a shift at one frequency across ears, one subject showed shifts at two frequencies, and two subjects showed shifts at three frequencies. Sixty percent of the shifts occurred in the left ear. The high frequency thresholds of the two subjects who demonstrated shifts at three frequencies were examined. No clear relationship was found to exist between the conventional frequency shifts and high frequency threshold changes.

The results of the pre- and post-primary speech intelligibility tests are presented in Table 6. They show, quite clearly, that noise exposure during primary flight training had no effect on the subjects' ability to discriminate speech in noise.

Percent affirmative responses to the 24 questions that were asked of the subjects in the questionnaire are summarized in Table 7. A copy of the complete questionnaire may be seen in Appendix B. The first question, which shows a 53 percent affirmative response (58 subjects) was a purely subjective response question. If marked "yes," the subject was then requested to indicate on a nine point scale the degree to which he was bothered by loud noises. A rating of 1 represented "slightly," 5 "moderately," and 9 "extremely." The mean rating for the group was 3.8. The largest percentage of subjects (22 percent) responded with a rating of 2

A substantial portion of the subjects indicated they had been exposed to potentially hazardous noise prior to, or immediately after, entry into

Table 6

Mean pre- and post-primary speech intelligibility test * scores for the 108 subjects.

	Ear	Mean Percent Correct Response	Standard Deviation
Pre-Primary	R	78.8	5.6
Post-Primary	R	80.6	4.3
Pre-Primary	L	78.4	6.0
Post-Primary	L	79.3	5.9

*Modified Rhyme Test

Table 7

Rank ordered percent affirmative responses for the 24 item pre-primary subject questionnaire. N=108.

Question	% Yes	Question	% Yes
At all bothered by loud noise	53	Serious injury	10
Drove recreational vehicle	48	Played in rock group	10
Surgery	46	Other noise exposures	10
Noisy machinery	45	Sinus or allergy	7
Wore ear protection	43	Serious illness	6
Sports shooting	37	Family history of hearing loss	6
Flew private aircraft	33	Antibiotics	6
Operated heavy equipment	28	Earaches/drainage	6
Fired military weapons	28	Problems in speech discrimination	5
Cold today	21	Flew military aircraft	5
Physical discomfort from loud noises	16	Currently exposed to loud noise	5
Tinnitus	14	Dizziness	0

the military. The consequencies of this were evidenced in the pre-primary conventional frequency hearing threshold data. The entry "wore ear protection" applies almost exclusively to the time period when the subjects were being familiarized with the .45 caliber pistol as part of their Schools Command training. It is interesting to note that none of the 108 subjects admitted to ever experiencing dizziness.

It may well be that the life style of the potential military aviator is such that he will likely have sustained some degree of noise-induced hearing loss prior to this entry into the military. It is felt that it would be informative to gather similar questionnaire data on non-aviation subjects of the same age.

CONCLUSIONS

The data obtained in this study indicate quite clearly that noise encountered by AOC's in T-34 aircraft during primary flight training has no significant effect on their ability to hear conventional or high frequencies, or their ability to discriminate speech in noise. It is not known whether such effects occur during subsequent phases of training as the students are exposed to different aircraft acoustical environments. It is recommended that additional studies of this type be undertaken to obtain hearing threshold level data on AOC's as they complete each major phase of flight training (helicopter, prop, and jet).

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APPENDIX A

BRIEFING READ TO SUBJECTS

This briefing is being read to you simply as a means of ensuring that the information presented is complete and that all subjects receive identical information.

You are a part of a study of the hearing of naval aviators. As you probably have heard, exposure to loud noise over a period of time without the use of ear protection can damage elements of the inner ear and therefore hearing. It is possible that even with ear protection, some susceptible individuals might incur some degree of hearing loss in the high frequencies (around 4,000 Hz). The purpose of this study is to determine whether or not we may be able to identify these individuals before they develop a loss at 4,000 Hz by testing for shifts in their very high frequency hearing (up to 18,000 Hz).

To answer this question requires that we perform a number of hearing tests on a large group of individuals before and after a major segment of their aviation training. We are cooperating with people at Memphis State University and they will be responsible for testing at bases away from the Pensacola area. The next time we test you will be just after your completion of primary training. We will contact you at that time for scheduling the retest.

The testing this morning will require about two hours of your time. Details concerning each of the tests you will take will be given to you just before each one.

The results of this study will be of great importance to naval aviation. We trust that we will have your maximum attention and cooperation during the test runs.

Are there any questions?

APPENDIX B
QUESTIONNAIRE
LONGITUDINAL AUDIOMETRIC STUDY

NAME ______________ RANK _____ SERIAL NO. _________ DATE _______

AGE ____ SEX ____ DOB ________ LOCAL ADDRESS ______________

PHONE __________ PIPELINE ____________________

MEDICAL HISTORY:

If you respond yes to any of the following questions, please give details in the spaces provided.

YES	NO	
☐	☐	Serious Illness ______________
☐	☐	Serious Injury ______________
☐	☐	Surgery ______________
☐	☐	Family history of hearing loss ______________
☐	☐	Antibiotics (especially mycin group) ______________
☐	☐	Sinus or allergy ______________
☐	☐	Do you have a cold today ______________
☐	☐	Do you have problems understanding speech in any situation ______
☐	☐	Do you have head noises: What does it sound like ______________
		One or both ears ______________
		How often ______________
		How long does it last ______________
		Continuous or intermittent ______________
		Under what circumstances do you hear it ______________
☐	☐	Earaches and/or draining ears ______________
☐	☐	Dizziness ______________

NOISE EXPOSURE HISTORY:

Again, if you respond yes to any of the following questions, please give details in the spaces provided.

YES	NO	
☐	☐	Played instrument in a Rock music group ______________
☐	☐	Operated heavy equipment (tractor, bulldozer, etc.) ______________

NOISE EXPOSURE HISTORY (cont'd):

YES	NO	
☐	☐	Worked around noisy machinery (forge, turbines, etc.) ________
☐	☐	Engaged in sports shooting ________
☐	☐	Flew private aircraft (pilot or passenger) ________
☐	☐	Drove recreational vehicles (motorcycles, dune buggies, etc.) ________
☐	☐	Flew military aircraft (pilot or crew) ________
☐	☐	Fired military weapons ________
☐	☐	Other noise exposure not covered above ________
☐	☐	Wore ear protective devices when engaged in one or more of above activities ________
☐	☐	Experienced physical discomfort from loud noise (pain, tickle, fluttering, nausea, etc.) ________

CURRENT NOISE EXPOSURE:

If you respond yes to questions below please give details in the spaces provided.

YES	NO	
☐	☐	Are you currently exposed to any high level noises: If yes, give details, then proceed to questions below. ________

Time elapsed since most recent noise exposure ________

Duration of most recent noise exposure ________

Ear protection worn ________

SUBJECTIVE REACTION TO NOISE:

YES	NO	
☐	☐	Are you at all bothered by loud noises?

If so, please indicate the degree to which you are bothered on the following 9 point scale:

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Slightly Moderately Extremely

END

Please sign your name at right below.

SIGNATURE

APPENDIX C

Table 1

Ranges of high frequency hearing levels in dB (coupler SPL) for the pre- and post-primary test runs. N=108.

Frequency (kHz)	Pre-Primary Test #1		Pre-Primary Test #2		Post-Primary	
	Left Ear	Right Ear	Left Ear	Right Ear	Left Ear	Right Ear
4	-16 to 62	-18 to 58	-16 to 65	-16 to 46	-16 to 65	-15 to 55
6	-18 68	-20 63	-15 68	-20 65	-12 70	-11 52
8	-15 68	-17 63	-18 65	-16 62	-20 65	-14 65
9	-16 65	-22 64	-14 63	-30 60	-16 66	-12 60
10	-8 65	-18 60	-8 64	-9 57	-15 58	-8 65
11	-15 62	-10 65	-10 63	-14 65	-15 65	-14 65
12	-5 68	-10 65	-5 66	-2 68	-10 70	-5 61
13	-11 70	-3 65	-3 66	0 67	-13 72	-7 65
14	0 75	-6 68	-3 71	-10 68	0 73	-5 70
15	2 77	-3 72	4 76	0 72	-3 75	2 72
16	2 80	0 75	7 76	-2 75	8 76	1 78
18	30 82	30 80	36 80	25 82	23 81	19 80

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Table 2

Correlation coefficients (r) obtained for the two pre-primary test runs and between the second pre-primary and the post-primary test runs. N=108.

	Correlation Coefficients			
	Pre-Primary Tests 1 and 2		Pre-Primary Test 2 and Post-Primary	
Frequency (kHz)	Left Ear	Right Ear	Left Ear	Right Ear
4	.88	.69	.75	.59
6	.80	.76	.68	.68
8	.83	.71	.69	.63
9	.82	.70	.66	.51
10	.82	.70	.58	.59
11	.80	.77	.70	.74
12	.75	.77	.69	.55
13	.75	.70	.64	.62
14	.73	.74	.66	.63
15	.73	.74	.69	.72
16	.79	.71	.58	.72
18	.82	.62	.74	.59

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Table 3

Ranges of conventional frequency hearing levels in dB (ANSI 1969) for the pre- and post-primary test runs. N=108.

Frequency (kHz)	Pre-Primary Left Ear		Pre-Primary Right Ear		Post-Primary Left Ear		Post-Primary Right Ear	
.25	-5 to	20	-5 to	15	-5 to	25	-5 to	15
.5	-5	25	-5	25	-5	25	-5	20
1	-5	25	-5	20	-5	25	-5	20
2	-5	30	-5	25	-5	25	-5	20
3	-5	60	-5	45	-5	60	-5	45
4	-5	80	-5	45	-5	75	-5	55
6	0	90	-5	80	-5	90	-5	90
8	-5	65	-5	70	-5	70	-5	75